GREEN STORAGE PRODUCTS: Efficiency with ENERGY STAR™ and Beyond

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Cloud Infrastructure Group, EMC
Abstract

- **GREEN STORAGE PRODUCTS: Efficiency with ENERGY STAR™ and Beyond**

- This talk will outline storage-specific topics related to energy-efficiency, including metrics for measuring, managing and designing for power. We will overview ongoing efforts in the SNIA Green Storage TWG and in partnership with the EPA ENERGY STAR™ program, The Green Grid, the DMTF and other industry groups.
Outline

- Current state of affairs and industry trends
  - Power measurement
    - storage subsystems
    - idle and active modes
    - power supply loading / efficiencies
    - power measurement & monitoring equipment
  - Green metrics and taxonomy
    - measuring green-ness
    - storage product categories
  - ENERGY STAR™ for Data Center Storage
    - update and overview
  - SNIA green storage efforts
    - unplugged fests, green standards, workshops, alliances
Cost of Data Storage

IDC #212714, “The Real Costs to Power and Cool All the World’s External Storage” – June 2008 Dave Reinsel
Chart used by permission of IDC
What impacts power consumption

- Storage capacity / usage efficiency
  - increasing data → larger capacity → more disks
  - redundant copies → magnify capacity needs
  - variability in usage and utilization → inefficient allocation of space
  - What is valuable data? What is the retention policy?

- Data transfer rate / access speed
  - high I/O bandwidth → higher rotational speed; striping across many drives
  - low access times → faster actuators; higher rotational speeds; caches
  - How fast and immediate must data be available? (time-to-data)

- Data integrity
  - 25% of “digital universe” is unique, but 75% are replicas / duplicates
  - partly to ensure data integrity and survivability; partly wasteful

- Data availability / system reliability
  - RAID uses extra drives, plus redundant power supplies, fans, controllers,
  - How valuable is data? How likely are failures? How fast must data be available?
Potential paths to “green”

- Improve usage efficiency
  - De-duplication
  - Thin provisioning

- Minimize energy consumption
  - Improved component designs – high-efficiency power supplies, advanced & flexible drives
  - Variants of MAID – idle and spin-down

- New technologies
  - Solid state storage
  - Hybrid system designs (opportunity to rethink)

must be driven by metrics / standards / guidelines
System design, complexity and redundancy vary depending on applications & usage

Component designs, software features, and workload affect power consumption and efficiency

- Switches
- Appliances
- Disk Arrays
- PDUs (Power Distribution Unit)
- UPSs (Uninterruptible Power Supply)
- Apps
- Software
- Power Supplies
- Fans
- Controllers
- Hard drives
1 - Redundant power supplies are standard, except in the smallest systems

2 - Significant mechanical components, require dual-output power supplies (12V, 5V)

3 - Power supplies often custom-designed for reliability

*presented by EPA at ENERGY STAR Computer Server Stakeholder Meetings; July 2008
Idle Power vs. Active Power

- **Idle Mode**
  - storage system is protecting data, ready to process IOs
  - background maintenance & optimization tasks on-going
  - factors: time-to-data, overhead electronics, fan, maintenance
  - systems are idle large fractions of the time

- **Active Mode**
  - storage system is carrying out IOs
  - background tasks continue in parallel
  - factors: workload (seq/random), response time, throughput
  - evaluate a variety of workloads, plus sustained peak power
Example of Power Measurement

- Ideally, systems consume minimum power in all modes
  - Example system consumes significant power in idle (80% of max)
- % of time in Idle versus Active depends on storage type, application and workloads; available optimizations will vary
- Power consumed is not linearly proportional to workload (indicates potential room for improvement)
Measurement Tools

- Variety of power monitoring & measurement tools available
  - rack-mounted, networked PDUs for continuous operational monitoring
  - more accurate power meters w/ data logging capabilities are preferred for system characterization and benchmarking
  - select a tool based on accuracy, features, Amp/V/Watt levels
  - refer to SPEC website for recommended measurement devices and settings [www.spec.org/power_ssj2008/docs/device-list.html](www.spec.org/power_ssj2008/docs/device-list.html)

- Measure operating conditions (temp, humidity, altitude) w/ power to establish baselines and understand system behaviors

- Both total and sub-system power consumed are valuable info.
Green Metrics – purpose / challenge

- Need scientific measures and common vocabulary to assess “green” performance
  - assist in data center design, operational monitoring/tuning and regulatory compliance
- Storage systems have many modes and outputs
  - a single metric (such as GB/Watt) may not reflect the characteristics or capability of the whole system
  - some system “outputs” are not all easily quantifiable
- Multiple metrics may be weighed and combined to form a single metric (e.g. annual energy bill)
  - will vary with usage and system; your mileage will vary
Metrics motivation

Workload considerations
- **Data at rest – Idle power (GB/Watt)**
- Data on the move – Throughput (MB/s)
- Data at work – Performance (IOPS)

Potentially useful metrics
- GB per Watt; MB/s per Watt; IOPS per Watt
- Power supply efficiency; CO₂ footprint
- Total annual energy bill (ultimately determined by usage)

Reliability / availability / serviceability considerations
- Latency (time-to-date)
- Redundancy level (RAID efficiency, resilience to failures)

Department of Energy labeling program

Computer Server example

**EPA ENERGY STAR certification program**
Storage taxonomy

- Need a taxonomy (product classification) to enable fair comparisons among similar storage products
  - e.g. for motor vehicles – motorcycles, cars, trucks
- Similar green metrics may apply to all product categories, but different values establish best-in-class
- Unique considerations apply to special categories
  - e.g. amphibious cars, skid steer loaders, tanks
- Clear taxonomy will simplify comparisons and aid regulatory efforts
Measurement Standard

- Storage taxonomy
- Measurement conditions
- Idle metric
- Reporting results
## Taxonomy – Categories

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Online</th>
<th>Near online</th>
<th>Removable Media</th>
<th>Virtual Media Library</th>
<th>Appliance</th>
<th>Interconnect</th>
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<td>Access Pattern</td>
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<td>Random</td>
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- Six categories, covering most storage industry products
## Taxonomy – Categories

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- 22 total “buckets” covering the breadth of the industry
### Most common storage systems

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<tr>
<td>Maximum Configuration 2</td>
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## Taxonomy – Appliance & Interconnect

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<td>Maximum Port Count (n)</td>
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<td>Extender: ( \leq 4 )</td>
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</table>
Storage Power – Idle

Equation 6-1: Average Idle Power

\[ P_i = \frac{\sum W_i}{n} \]

Where:
- \( P_i \) is average idle power
- \( W_i \) is power in watts measured in each sampling interval \( i \)
- \( n \) is the number of samples gathered by the power meter during the measurement interval.

Equation 7-1 SNIA Idle Power Metric

\[ P = \frac{C}{P_i} \]

Where:
- \( P \) is the SNIA Idle Power Metric
- \( C \) is the total capacity of the SUT
- \( P_i \) is the average idle power
Many variations in workloads
Many variations in system configuration
Takes us into the realm of benchmarking
Desired Metric – “Productivity”

Many possible definitions – must balance simplicity against applicability

• “typical workload”, with levels

• “four corners”, maximum performance, maximum power

• detailed performance benchmark – results/W

Storage Performance Council

Standard Performance Evaluation Corporation

The Green Grid Productivity Proxies

example – Proxy #4 – bits/kilowatt-hour
Complications

- Max power $\neq$ Max performance

**Single disk drive power profile**

**Storage Modeling for Power Estimation**

Miriam Allalouf • Ronen I. Kat • Yuriy Arbitman • Balen Segal • Michael Factor • Kalman Meth • Dalit Naor; IBM Haifa Research Labs; SYSTOR 2009; May 2009

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"Storage Modeling for Power Estimation", Miriam Allalouf, Yuriy Arbitman, Michael Factor, Ronen Kat, Kalman Meth, and Dalit Naor; IBM Haifa Research Labs; SYSTOR 2009; May 2009

"The Next Frontier for Power/Performance Benchmarking: Energy Efficiency of Storage Subsystems" Klaus-Dieter Lange

Hewlett-Packard Company, 11445 Corporate Center Dr, W, Houston, TX-77070, USA
KLange@hp.com

**Abstract:** The increasing concern of energy usage in datacenters has drastically changed how the IT industry evaluates servers. The energy conscious selection of storage subsystems is the next logical step. This paper first quantifies the possible energy savings of utilizing modern storage subsystems by identifying inherent energy characteristics of next generation disk IO subsystems. Additionally, the power consumptions of a variety of workload patterns is demonstrated.

**Keywords:** SPEC, Benchmark, Power, Energy, Performance, Server, Storage, Datacenter.

1 Introduction

Today's challenge for datacenters is their high energy consumption [1]. The demand for efficient real estate in datacenters has moved to more power efficient datacenters. This increasing concern of energy usage in datacenters has drastically changed how the IT industry evaluates servers. In response, the Standard Performance Evaluation...
Outline

- Current state of affairs and industry trends
- Power measurement
  - storage subsystems
  - idle and active modes
  - power supply loading / efficiencies
  - power measurement & monitoring equipment
- Green metrics and taxonomy
  - measuring green-ness
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- ENERGY STAR™ for Data Center Storage
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  - unplugged fests, green standards, white papers / workshops, alliances
## ENERGY STAR™ for Computer Servers

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<td>15 May 2009</td>
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29 months from letter to live

7 server results posted as of 1 September 2009
HP ProLiant Energy Star for Servers
HP ProLiant Servers with Thermal Logic Technology Are Energy Star Qualified

Get started

- ProLiant G6 Servers
- ProLiant Blog
- Virtual IT Center
- Energy Star Website
- Got questions? HP sales expert contact

Energy Star HP ProLiant DL...

The HP ProLiant DL380 G6 Server is designed to deliver on its heritage of engineering excellence with increased flexibility and performance.

Learn more >>
# ENERGY STAR® Power and Performance Data Sheet

**DL360 G6; 504633-xx1**

## System Characteristics

<table>
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<th>Characteristic</th>
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<tr>
<td>Available Processor Sockets</td>
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<tr>
<td>Available DIMM Slots / Max Memory Capacity</td>
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<td>ECC and/or Fully Buffered DIMMs</td>
<td>Yes, ECC and Registered DIMM (RDIMM) memory</td>
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<td>Available Expansion Slots</td>
<td>Up to 2 PCI-E and up to 1 PCI-X, not to exceed 2 total</td>
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<td>Minimum and Maximum # of Hard Drives</td>
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<td>Redundant Power Supply Capable?</td>
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<td>Power Supply Make and Model</td>
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<td>Power Supply Output Rating* (watts)</td>
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<tr>
<td>Minimum and Maximum # of Power Supplies</td>
<td>1 and 2</td>
</tr>
<tr>
<td>Input Power Range (AC or DC)</td>
<td>100-240VAC</td>
</tr>
<tr>
<td>Power Supply Efficiency at Specified Loadings*</td>
<td>85.5%@10%, 90.1%@20%, 92.2%@50%, 91.6%@100%</td>
</tr>
<tr>
<td>Power Supply Power Factor at Specified Loadings*</td>
<td>0.816@10%, 0.923@20%, 0.956@50%, 0.982@100%</td>
</tr>
</tbody>
</table>
PowerEdge Servers Engineered with Energy Smart Technologies

COMPUTE MORE CONSUME LESS

Dell and Energy Star

Dell is committed to maximizing IT productivity and saving energy. In order to provide our customers with lower overall power consumption in the data center, we engineer our products to rigorous standards to achieve industry-leading performance per watt. These products also qualify for the new ENERGY STAR® specifications sponsored by the U.S. Environmental Protection Agency and the Department of Defense.

To learn more about our latest Energy Star certified servers, please review the following data sheets highlighting the qualifying platforms:

- Dell PowerEdge R710 Energy Star Datasheet
- Dell PowerEdge R810 Energy Star Datasheet

Dell PowerEdge Servers: Addressing Your Energy Needs

Limitations on space, power and cooling capacity combined with rising energy costs present enormous challenges for IT environments. Our newest Dell PowerEdge servers feature Energy Smart technologies designed to reduce power consumption while increasing performance and capacity based on Dell’s five key technologies:

- Dell Energy Smart Power Supplies
  Energy Smart Power Supply Units (PSUs) are engineered and “right sized” to achieve some of the highest efficiencies in the industry by taking unneeded overhead out of the server power envelope.

Storage Developer Conference 2009
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C. Standard Information Reporting Requirements

Manufacturers must provide a standardized Computer Server Version 1.0 Power and Performance Data Sheet with each ENERGY STAR qualified Computer Server. This information must be posted on the Partner’s Web site where information on the qualified model, or qualified configurations, is posted. Manufacturers are encouraged to provide one data sheet per qualified configuration, but may also provide one sheet per Product Family (as defined in Section 1.T above) with data on the Computer Server’s power and performance for maximum, minimum and typical configurations (as defined in Sections 1.U – 1.W, above).

If one data sheet is used to represent many configurations under one Product Family, partners should, when available, also provide a link to a more detailed power calculator where information on the power use of specific system configurations can be found.

Templates for the Server Version 1.0 Power and Performance Data Sheet can be found on the ENERGY STAR Web page for Computer Servers at www.energystar.gov/products.

Note: EPA has changed the Standard Information Reporting Requirements to harmonize with the new definition for Product Families in this specification.

EPA has also included text that a template for the Power and Performance Data Sheet will be posted on the ENERGY STAR products page for Computer Servers. A revised draft of the Power and Performance Data Sheet has also been included with this Draft 4 specification. EPA encourages all stakeholders to review this latest version and provide comments to EPA.

The revised data sheet includes a few key changes that EPA would like to make stakeholder aware of:

- Since SPECpower is no longer being referenced for Idle power testing, manufacturers are not required to report SPECpower test results on the data sheet. However, EPA is still requiring testing and reporting of at least one benchmark, of the manufacturer’s choosing, for inclusion on the data sheet.

- EPA is requiring that Full Load (100%) power be tested and reported along with the method used to determine Full Load power indicated on the data sheet. EPA believes this will provide buyers the necessary information on the full power range of the Computer Server while also allowing EPA to collect valuable data which may be useful in the development of the Tier 2 specification.
# ENERGY STAR ™ for Data Center Storage

<table>
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<td>Draft 1</td>
<td>March 2010 (*), TBD</td>
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<td>March 2010</td>
<td>Final 1.0</td>
<td>March 2010 (*), TBD</td>
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11 months from letter to live

“since we have the learning from the Server spec, we expect this process to go much quicker for Storage” – Andrew Fanara, March 2009 in San Jose

“this is one of the most complex areas we have tackled to date” – Andrew Fanara, July 2009 in San Jose
Observations from Stakeholder Meeting

- EPA ENERGY STAR™
  - Open and willing to listen
  - Learning
  - Collaboration with industry is a key goal (while meeting the EPA needs and mission)

- Audience
  - Wide beyond-SNIA participation
  - The Green Grid, Wikibon, PG&E, ClimateSavers
  - end-user orgs vie phone (Vanguard, Wachovia, Deutsche Bank)
Goals for Data Center Storage

• Encourage widespread adoption of energy efficient hardware and software strategies,
• Provide purchasers with the means to identify the most energy efficient enterprise storage solutions for their specific end-use application, and
• Provide tools and information to designers and managers looking to improve the efficiency of data center operations
Litmus Test

- There are numerous product features, functions, and data management strategies that enable energy savings in data center storage.

- There is only one end result that matters: The ability to do more useful work, while consuming fewer resources, in a verifiable and quantifiable manner.
Outline

- Current state of affairs and industry trends
- Power measurement
  - storage subsystems
  - idle and active modes
  - power supply loading / efficiencies
  - power measurement & monitoring equipment
- Green metrics and taxonomy
  - measuring green-ness
  - storage product categories
- ENERGY STAR™ for Data Center Storage
  - update and overview
- SNIA green storage efforts
  - unplugged fests, green standards, white papers / workshops, alliances
SNIA Green Efforts

- SNIA Green Storage Initiative (GSI) and SNIA Green Storage Technical Work Group (TWG)
  - on-going efforts to develop data-driven green standards & metrics
  - power measurements at multi-vendor “unplugged” fests
  - alliances with other active green organizations
    - (The Green Grid, 80PLUS/Climate Savers, DMTF, SPEC, SPC)
  - collaboration with EPA on the ENERGY STAR™ program

- Whitepapers / workshops
  - three tutorials at SNW; online tutorials available (www.snia.org/education/tutorials)
  - white papers from GSI
“Green is good” – for multiple reasons
- a great engineering problem – doing more with less
- saves money – great investment payback
- helps save the planet – significant leverage

Get involved with SNIA Green efforts
- weekly discussions, regular face-to-face & “unplugged” fests (TWG)
  - Upcoming face-to-face meeting at USENIX LISA on November 2 & 3 in Baltimore
  - Get a power meter and try the measurement spec on your own systems (!)
- education and promotion (GSI)
- promote these industry-wide efforts within your company

Learn about wider green technology and opportunities
- online resources; workshops by SNIA, EPA, The Green Grid

Share your experience / knowledge
References

- SNIA Green Storage Initiative – www.snia.org/green
- The Green Grid – www.greengrid.org
- EPA ENERGY STAR™ (Data Center Storage – www.energystar.gov/index.cfm?c=new_specs.enterprise_storage)
- DOE Federal Energy Management Program – eere.energy.gov/femp
- Power calculators at various vendor sites
- SNIA Green Storage Outreach
  - www.snia.org/forums/green
Thank you for your attention!

Please send any questions or comments on this presentation to SNIA: greentwg@snia.org

Many thanks to the following individuals for their contributions to this tutorial.

Patrick Chu  SNIA Green Storage Initiative members
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